COMPUtational tools for imaging and modeling of cardiac electro-mechanics

TRACK Number 5000

Joakim Sundnes\*and Hermenegild Arevalo‡

\* Simula Research Laboratory

Oslo, Norway

sundnes@simula.no

‡ Simula Research Laboratory

Oslo, Norway

hermenegild@simula.no

**Key words:** cardiac models, electrophysiology, biomechanics, biophysics, biomedicine.

ABSTRACT

Computational models of cardiac electrophysiology and mechanics have been developed over several decades, and have benefited from a continuous improvement in numerical methods, computer hardware, medical imaging and experimental techniques. This development has allowed scientists to build more and more complex and realistic models of this vital system, incorporating detailed descriptions of its anatomy and physiology in health and disease, and patient-specific cardio-vascular models have emerged as predictive tools for clinical decision support [1]. However, in spite of substantial progress, the full potential of computational models in cardiac research is far from being realized, and clinical use of computational models remains very limited. This limited uptake can partly be attributed to the challenges of developing, parameterizing, and solving predictive and reliable models of individual patients and research subjects. Biological processes are extremely complex and span a wide range of spatial and temporal scales, and the models of interest are typically formulated as strongly non-linear partial differential equations. These equations are challenging to solve numerically, essential physiological parameters vary considerably between individuals. Capturing these variations typically requires estimating model parameters based on sparse and noisy experimental data, and both uncertainty quantification and validation of the resulting models remain challenging. In recent years there has been growing interest in combining biophysical models with machine learning tools, in particular deep learning, for classification and prediction in medicine [2]. Deep learning has proven to be extremely powerful for certain applications, but training the models requires huge datasets which are often not available for medical applications. Combining machine learning with biophysical models can potentially reduce the need for training data, and thereby greatly increase the applicability of the methods.

This minisymposium will address many of the computational challenges involved in the modelling and imaging of cardiac electrophysiology and mechanics. Topics of interest include, but are not limited to:

* Anatomically and physiologically detailed models of cardiac electrophysiology and mechanics;
* Combining biophysically based models with machine learning;
* Efficient numerical methods and parallel algorithms for cardiac electro-mechanics, in particular those related to the solution of nonlinear systems of partial differential equations;
* The development of models for cell electrophysiology and contraction, as well as constitutive relations for passive and active heart tissue;
* Uncertainty quantification in models of cardiac electro-mechanics;
* New and emerging multiscale models for cardiac electrophysiology and mechanics
* Inverse problems and parameter estimation;
* Applications of the models for clinical work and biomedical science.

**REFERENCES**

1. S.A. Niederer, J. Lumens and N.A. Trayanova, Computational models in cardiology, *Nat. Rev. Cardiol*., Vol. 16, 100–111, 2019.
2. M. Sermesant, H. Delingette, H. Cochet et al., Applications of artificial intelligence in cardiovascular imaging, *Nat Rev Cardiol,* Vol. 18, 600–609, 2021.